AEROSPACE REPORT NO.
ATR-74(7334)-1. VOL. IV
PART 1

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Space Shuttle/Payload Interface Analysis (Study 2.4) Final Report

Volume IV

Business Risk and Value of Operations in Space (BRAVO)

Part 1 - Summary

Prepared by
ADVANCED VEHICLE SYSTEMS DIRECTORATE
Systems Planning Division

15 February 1974

Prepared for OFFICE OF MANNED SPACE FLIGHT
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C.

Contract No. NASW-2472

Systems Engineering Operations
THE AEROSPACE CORPORATION

Aerospace Report No.
ATR-74(7334)-1, Vol. IV
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Part 1: Summary

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FOREWORD

The Space Shuttle/Payload Interface Analysis (Study 2.4) Final Report is comprised of five volumes, which are titled as follows:

- Volume I - Executive Summary
- Volume II - Space Shuttle Traffic Analysis
- Volume III - New Expendable Vehicle with Reusable Solid Rocket Motors
- Volume IV - Business Risk and Value of Operations in Space (BRAVO)
  - Part 1 - Summary
  - Part 2 - User's Manual
  - Part 3 - Workbook
  - Part 4 - Computer Programs and Data Look-Up
- Volume V - Payload Community Analysis

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1. INTRODUCTION

The Business Risk and Value of Operations in Space (BRAVO) Study is reported in four parts. The purpose of Part 1 is to summarize the study by describing the approach, operation of the procedures, and status in a general way. This part is useful as background information. The emphasis is on the philosophy behind the analytical techniques. Part 1 should aid those interpreting the results of BRAVO analyses as well as those carrying out the procedures. An overview of the BRAVO procedure itself is given in Section 2 of Part 2, the User's Manual. It is not repeated here. Part 3 contains a series of worksheets, some or all of which may be required to work each specific BRAVO problem. It is intended that, for each problem, the user start with a clean set of the appropriate forms from Part 3. The completed forms then become part of the record of each analysis. Part 4 contains the computer program listings and additional data banks required to operate the BRAVO procedures.

2. DEFINITION OF BRAVO

The name BRAVO refers to an analytical tool comprised of a very large data bank which has been organized and correlated so that it can be applied to specific space systems and ground systems configured to and responsive to user's needs. The procedures are designed to accept user's-need type inputs, define space systems and ground systems which will fulfill user's needs at comparable risks and, finally, make economic comparisons between the ground system and space system. The BRAVO tool fits problems best which can make use of current technology or extensions of current technology. It can also be adapted to applications requiring advanced technology when studies are available or can be made which define the advanced technology goals.

The BRAVO tool is intended for automated and manned satellite systems. In its current form, the BRAVO tool works best on application types of satellites intended for operation over a long period, i.e., communication systems, navigation systems, weather and earth observation systems, and normal variations and combinations of these. Its adaptability has been demonstrated by applying it to a solar cell power satellite system of advanced design. The BRAVO tool has also been tested by analyzing future communication satellites for international application and comparing the results with those of the Comsat Corporation.

3. BRAVO APPROACH

The concept of the BRAVO tool is that comparisons between ground systems and space systems should consider the function of the system, system risk, and system cost. The approach taken in developing the tool is that the ground system and space system should have equal capability to perform the function or service described as the potential user's needs. The risks are also made as nearly equal as possible between the space system and the ground system to be compared. One way this is accomplished is to configure the space system to have a risk equal to the ground system or the user's specified risk. With the STS as the space system launch vehicle, the risk associated with the system varies with satellite logistics (e.g., frequency of launch) or satellite reliability or both. With the STS, the satellite development risk can also be varied with changes in the development approach and expenditure, although the latter is not as significant as the outage problem[1].

When the capability and risk are equal, the system cost can be compared by an economic analysis between the space system and the ground system.

When accepting a user-established need for potential system outage for use in a BRAVO analysis, the analyst makes a check for reasonableness by comparing the outage requirement against such potential influences as atmospheric interference to system operation.

The approach for development of BRAVO techniques includes testing the analytical tool against other studies on the same user needs. Reasonable agreement can be expected between two studies utilizing different data banks and techniques if the inputs and ground rules are the same.

Ground rules for the BRAVO procedures include the following:

(1) The lowest cost approach for each system is utilized. In order to accomplish this, the alternative system approaches are configured, costed, and compared as a part of the

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(1) Development programs have been funded historically at a level consistent with their historical operating success. It is the historical operating success which is being represented in this analysis.

routine procedure. For instance, in a specific application, if the analyst is not sure whether the lowest cost approach would include spare satellites on orbit or not, both alternatives would be analyzed and the lowest cost approach meeting system requirements would be chosen.

(2) Unless the potential user specifies that a dedicated system is needed, the analysis considers shared system capability as well as dedicated systems for the application. Again, the choice between the two is made on the basis of minimum cost.

(3) It is assumed that the space systems to be analyzed will be operating in the space transportation system era, most likely 1985 or later. Several potential advantages for space systems are foreseen for the STS era:

   (a) Space system risks will be decreasing with the STS capability.

   (b) Space system buy-in costs may be decreasing.

   (c) Space system applications activity level has a potential for increasing.

   (d) Space system development lead times have a potential for decreasing.

(4) It is assumed that the user will accept typical STS era payload designs which follow design rules for STS payloads. Design rules for STS payloads may be found in References 1, 2, and 3.

(5) It is assumed in the economic analysis that no major surprises occur, such as large scale warfare or a large scale depression in the economy.

The BRAVO approach brings the user closer to the analysis. This advantage is thought to be unique. User inputs are used directly in setting up the analysis problem. The output of the analysis is primarily cost information and data which can be understood by most potential space users. Therefore, little understanding of space systems per se is required for the user to understand the study results. When the potential user establishes the demand for a function or service to be performed, it is presumed to be described in a

manner reflecting his own assessments of the market for his particular products or services. Therefore, the results of the analysis fit directly into the potential user's planning and thinking. It is also quite possible that the techniques developed for the BRAVO tool could be employed by a user directly to do an independent analysis.

4. OPERATION OF BRAVO PROCEDURES

The detailed explanation of BRAVO procedures is contained in Part 2 of this volume, the User's Manual. In order to accomplish these analyses, personnel with certain skills are required. The two lead personnel in the analysis are the space systems concept analyst and the ground systems concept analyst. These analysts should have broad technical backgrounds and considerable systems experience in the appropriate areas. They will both require the assistance of a systems cost estimator, and for some problems may need on-call or consulting help from specialists such as a telecommunications engineer, radar, microwave or IR engineers, and computer program operators. For the ground systems, manual calculator operator assistance may be required. For the space systems, personnel trained in the IBM APL interactive computer program operation and on the CDC 7600, as well as manual calculation assistance, are needed. The space system concept analyst will need also part-time help from a satellite design specialist and a reliability engineer. An economist will be helpful also in interpreting and/or iterating the results of the cost effectiveness analysis comparisons.

5. INTERPRETATION OF BRAVO RESULTS

The question to be answered by a BRAVO analysis is "When is it worthwhile going further with the space application in preference to the ground application to fulfill the user's needs?" The following rules of thumb are based largely on judgment:

(1) Whichever system has a competitive advantage greater than 20 percent in key economic parameters, such as the revenue required to make the system profitable, would be considered the best approach to take.

(2) If the space system and ground system were about equal (within $\pm$ 20 percent), then further study may be required to optimize, define, and reassess the economic comparison.

(3) If the comparison between the space system and the ground system is close but not equal (one system has an advantage of 20 percent to 100 percent), further study and another iteration on the analysis may be useful, particularly if technology changes in operating mode or additional systems sharing can be identified which could influence the comparison.

6. STATUS OF BRAVO DEVELOPMENT

The BRAVO tool capability is sufficient to analyze most normal space systems and comparable ground systems which fit the limitations (automated, application type space systems, etc.) if the user specifies the mission equipment. The capability developed to date also includes analysis of channel-type communications systems where the user has not specified the mission equipment. The mission equipment synthesis is accomplished with BRAVO procedures using the potential user needs as requirements. The capability also includes the ability to make rough estimates on potential earth observation satellite mission equipment characteristics appropriate for multi-user systems in the 1980's.

In future studies, it is planned to improve and extend the mission equipment synthesis capability for BRAVO, particularly in the earth-observation area. It is also planned to extend the limits of applicability of the economic analysis further into the future. Refinement of the satellite synthesis capability and extension of the ground system definition capability are also planned.

7. REFERENCES

1. Payload Analysis for Space Shuttle Applications (Study 2.2), Final Report, The Aerospace Corporation, ATR-73(7312)-1, 15 October 1972.

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3. Design Guide for Low-Cost Standardized Payloads, Lockheed Missiles and Space Company, LMSC-D154696, 30 April 1972.